NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN ANALYSIS OF THE
EFFECTIVENESS EVALUATION MEASUREMENTS
FOR COAST GUARD
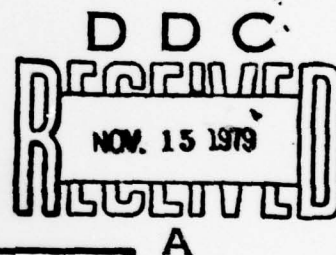GENERAL LAW ENFORCEMENT HELICOPTERS

by

James Alan Brokenik

September 1979

Thesis Co-Advisors: R.W. Sagehorn
                           J.W. Creighton

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for Coast Guard
General Law Enforcement Helicopters

by

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Lieutenant, United States Coast Guard
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Submitted in partial fulfillment of the
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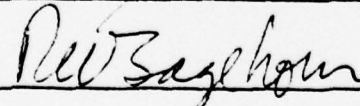NAVAL POSTGRADUATE SCHOOL
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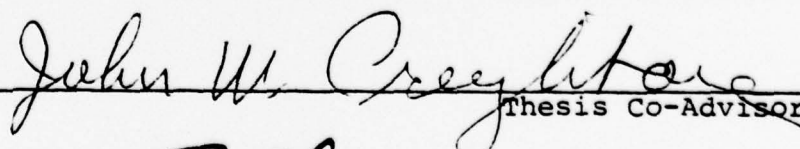
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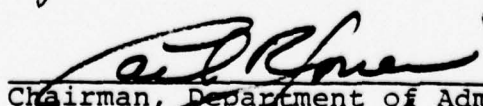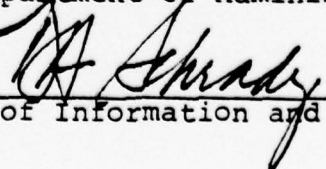
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goals and objectives. From this analysis a better under-
standing of this system is gained, alternatives are
developed, and recommendations for improved program and
resource performance evaluations are presented.

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I. INTRODUCTION

A. THE PROBLEM

Concern over the growing drug problem facing the United
States has led to increased enforcement efforts by federal,
state, and local law enforcement authorities. Emphasis has
been placed on interdicting these "controlled substances"
prior to entering the local distribution channels. The
concern is warranted. Some officials estimate that the
marijuana demand alone may exceed $5 billion annually.
[21:11] This translates into millions of regular marijuana
users with an increasing annual demand.

The Coast Guard has the primary responsibility for the
Enforcement of Laws and Treaties (ELT) of the United States
in the maritime region. Included, is the responsibility to
enforce the anti-smuggling laws which prohibit the unauthorized
importation of controlled substances of which marijuana and
other hard drugs are members. This responsibility has been
mandated for the Coast Guard by legislative acts and
continuous Congressional oversight, or review, during the
past decades.

Law enforcement is only one of several mission areas of
the Coast Guard. In this multi-mission format, resources,
of which personnel, vehicles, and facilities are all included,
must be allocated so as to fulfill all of the basic mission

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responsibilities. This has become an extremely difficult task in this period of increasing inflation and the stated objective of the President to balance the national budget. The number of mission areas has been steadily increasing while the absolute strength of Coast Guard resources has remained constant. These factors in combination have caused a classic economic supply and demand problem.

In this type of climate a manager must be able to evaluate the accomplishments of his program as a whole and of the individual resources employed to perform it. He must be able to provide adequate services to all mission areas or be able to explain why not. Scarce resources must be employed so as to provide the maximum performance possible in all mission areas. Resources that are not thus employed cannot be replaced in the short term.

With the increased concern over drugs and the expected continuously increasing enforcement efforts, the question has been raised as to the future utilization of Coast Guard maritime law enforcement helicopters. Investigations into this question raised the larger issue that the present management evaluation methods used in the program planning did not provide a complete picture of reasonable goals. There has been no clear evaluation of present accomplishments and helicopter participation was being projected on the basis of the expected number of missions and flight hours required to achieve the stated goals.

A satisfactory measure of tangible
benefits from ELT efforts has not been
developed. The objectives of law enforce-
ment are to detect, deter, and interdict
violators. Penalties assessed represent
successful detection and interdiction, and
may deter the violator from repeating his
illegal activities. On the other hand,
a breakdown in the deterrent function
makes penalty assessment an artificial
measure of enforcement effectiveness.
[25:I-3]

It appeared that a closer look at program evaluative tech-

niques would have to be taken prior to a comprehensive

resource employment forecast could be made.

B. INTENT

It is the intent of this thesis to make contributions

toward the evaluation, in the Coast Guard, for more effective

resource distribution systems for the law enforcement programs.

In order to determine if a system is effective, evaluative

devices must be developed that will aid in these pursuits.

No specific solutions will be recommended for the

resource allocation problems faced by the Coast Guard today.

Changing program and Service resource requirements in general

make such suggestions worthless. Recommendations will be

presented for the improvement of the current evaluation

system which will aid in future resource allocation decisions.

C. ASSUMPTIONS

Certain assumptions were necessary for this thesis. The

study was limited to a comparison of the helicopter and the

ship/helicopter team while performing within the general law

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enforcement program. The data for these resources was readily available and it was representative of the program performance standards required for all of the various marine and air vehicles employed in this and similar programs.

It is assumed that the Coast Guard, with its operating presence in the maritime region and its function as the primary maritime law enforcement agency of the federal government, is best suited to provide support for the other government agencies involved in maritime law enforcement. These agencies which include the U. S. Customs Service, Immigration and Naturalization Service, and the Drug Enforcement Administration, have overlapping law enforcement responsibilities in the maritime region, but lack suitable resources to pursue them. As a result, general maritime law enforcement within the Coast Guard will increase and will surpass all other law enforcement programs within the Service by the end of the 1980's.

In order to rank performance within the total structure of Coast Guard law enforcement programs it must be assumed that general and fisheries enforcement programs are comparable. This is based on the common elements of surveillance, detection, and apprehension found in both programs.

The violator of the customs and navigation laws of the United States, the smuggler, has to be viewed as a rational decision maker in an economic context. The violator has chosen illegal activities from which he expects net returns

to far exceed those which he could have received for equal time spent in legal pursuits. This activity does carry some risks of apprehension and punishment. Presently the probability of being caught while engaging in smuggling operations in the maritime region is very small. The violator is assumed to behave so as to maximize his gains and avoid being apprehended. To do this he will use the best equipment available and he will conduct his activities in areas where he will encounter the least possible law enforcement activity.

D. METHODOLOGY

The data used in this thesis came from Coast Guard statistical summaries, vessel patrol reports, and various studies conducted by and for the Service. This data reflects the current operating and reporting standards for Coast Guard programs. The reporting format was amended during calendar year 1978 so that ELT statistics would be accurately divided between general law enforcement and fisheries enforcement. Prior to this time it is not possible to accurately quantify all ELT patrol efforts for either of the two programs.

Additional background data was gathered through interviews with Coast Guard Headquarters staff personnel, Coast Guard District law enforcement staff personnel, and operational unit personnel. In addition, interviews were conducted with civilian law enforcement officers and supervisors and federal enforcement personnel including the Federal Bureau of Investigation, the U. S. Customs Service, and the Drug

Enforcement Administration. Printed background material was

obtained from local libraries and the Administrative Sciences

faculty collections.

The intentions of this thesis will be accomplished through

the analysis of the management control evaluation system used

in conjunction with the current Coast Guard General Law

Enforcement Program. The evaluation techniques and the

associated reports and historical data base will be related

to current enforcement goals and objectives. From this

analysis, a better understanding of the system will be gained,

and recommendations for improved and more complete resource

and program performance evaluation will be made.

II. BACKGROUND

A. HISTORICAL ENFORCEMENT

At this point it is valuable to present a brief history of the Coast Guard's law enforcement missions and responsibilities which preceded the current multi-mission resource allocation problems. The numerous and often seemingly unrelated enforcement missions have been acquired in a piecemeal fashion through a combination of normal growth and consolidations with various federal regulatory agencies.

The original statutory authority for Coast Guard involvement in maritime law enforcement activities dates back 189 years to 1790. Alexander Hamilton, the first Secretary of the Treasury, sought and obtained from Congress the authority to establish a seagoing military service which would enforce the nation's economic tariffs. The act provided for "Officers of the Customs" and empowered these officers to assist in the collection of customs revenue. This organization was the nucleus of the present day Coast Guard.

The regulatory and enforcement duties of the Coast Guard have gradually been expanded during the years since 1790. Various regulatory agencies have been created by legislative enactments or by Executive Order and then merged with the Service. A prime example of this is the Steamboat Inspection Service. It was originally created in 1852 to regulate, inspect, and license personnel and vessels propelled in whole

or in part by steam. Broad enforcement experience has been concentrated by such mergers in a small, diverse, maritime organization.

The National Prohibition Act, or the Volstead Act, became effective on January 17, 1920. The fourteen year period that the United States had national prohibition presented the Coast Guard with one of its greatest challenges in the law enforcement mission area. Those years of wide-spread smuggling activities were replete with lessons for posterity. Many of those experiences are being relearned in today's efforts to curb the trafficing of marijuana and other hard drugs.

One common point of speculation is that given that the total of the law enforcement efforts of the nation could not stop the flow of alcohol during Prohibition, is there even a possibility of stopping the flow of drugs today? Although it is not the intent of this thesis to pursue the answer to this question, a brief comparison of the striking similarities is of interest and benefit.

During Prohibition there were three primary sources of illicit alcohol available. Stills were prevalent across the country, and many persons made their own alcohol at home. The third source was foreign countries where alcohol was legally produced and then smuggled into the United States. These same three primary sources exist today for controlled substances. Smuggling large quantities across the maritime frontiers is a major source of supply for American drug markets.

It quickly became apparent to the politicians, law enforcement officials, and the general public that organized criminal elements had taken control of the liquor business and had maneuvered this control into a virtual monopoly. This control allowed for expansion into other areas of interest and promoted widespread political corruption. A similar realization has occurred with the knowledge that drugs are a high profit commodity. This ready source of cash has provided the means for organized criminal elements to diversify into other areas and endeavors both legal and illegal in nature. During Prohibition, as is often the case, law enforcement agencies were overwhelmed with the magnitude of these organizations.

> The effects of prohibition have been felt down to the present time and will probably continue to be felt for decades yet uncounted. Prohibition made the Roaring Twenties roar. It engendered the spirit that to beat the law was smart. Almost everyone was doing it, and it became an accepted part of life...So a widespread disrespect for law was born, and it flourished; it has filtered down through the years. [20:157]

This disrespect for the law and the socially accepted behavior towards drugs has had strikingly similar effects for the drug trade. The price and profitability of drugs has increased with demand. Large sums of money change hands when a shipment is sold and the drugs themselves can be readily converted into cash.

There is a major dissimilarity between Prohibition and the drug problems today. There is no serious move to legalize

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the importation, sale, and possession of large quantities of
controlled substances as there was in the late 1920's and
early 1930's. Although there is a possibility of the
decriminalization of marijuana at the user level, this would
not affect anti-smuggling law enforcement efforts as they
appear at this time.

B. LEGAL AUTHORITY

The law enforcement role of the Coast Guard today has
been expanded well beyond the limits experienced during the
Prohibition Era. In 1936 Congress passed legislation
formalizing the general, all encompassing maritime enforce-
ment mission for the Service. These laws forming the basis
for enforcement authority are found in the United States Code,
the systematic collection of federal statutes. The two most
important acts are as follows:

> 14 USC 2 -- The Coast Guard...shall
> enforce or assist in enforcement of all
> applicable Federal Laws on or under the
> high seas and waters subject to the
> jurisdiction of the United States.
>
> 14 USC 89 -- The Coast Guard may make
> inquiries, examinations, inspections,
> searches, seizures, and arrests upon the
> high seas and waters over which the
> United States has jurisdiction for the
> prevention, detection, and suppression
> of violations of laws of the United
> States. [27:15]

These two acts are generally considered the acts of
establishment of the Coast Guard enforcement authority. Other
specific enforcement duties are spelled out in Titles 14, 18,

and 19 of the United States Code with the associated procedures appearing in the Code of Federal Regulations.

With such broad responsibility for all maritime law enforcement, the Coast Guard has had to find some logical method to organize its efforts in the field. The Enforcement of Laws and Treaties Operating Program Plan is the document used for this purpose. It delineates the orderly progression of goals and objectives of the various ELT functions and describes how each relates to the formal Coast Guard Objectives.

> 1. Prevent loss of life and property resulting from hijacking and theft of vessels.
>
> 2. Prevent loss or damage to gear resulting from interference between fixed and mobile fishing gear operators.
>
> 3. Prevent loss of life and property resulting from civil craft loitering in marine danger areas.
>
> 4. Enforce Federal laws and international treaties relating to fisheries and marine mammals.
>
> 5. Enforce Federal laws and international treaties relating to crimes on vessels and in waters subject to United States jurisdiction.
>
> 6. Enforce Federal laws and international treaties relating to non-living resources.
>
> 7. Cooperate with other agencies where the use of Coast Guard resources is in the public interest. [25:APP VII]

Each of these seven functions is the subject of a separate Coast Guard law enforcement program.

This plan has been developed in such a way as to allow the application of zero-based budgeting concepts in the program elements. Prior to 1977, program analyses were more or less a cross between a projection of past activity and the program manager's intuition. As a result, there was a scarcity of meaningful historical information from which to draw because the decision process could not be duplicated in many instances.

The ELT environment is actually a dynamic system which exerts many requirements upon Coast Guard law enforcement resources. The Service has little or no ability to control the sources of these external demands but must respond to each. There exists a continuous need for Coast Guard participation in the formulation of international agreements and domestic laws and regulations relating to the ELT mission. This participation would allow for an accurate forecast of the future impact these legislative acts would have on Coast Guard operations. In this way problem areas could be anticipated, planned for, or avoided.

The ELT program interacts with a large number of outside agencies. Among these agencies are, to name a few:

    Department of Commerce
    Department of Justice
    Department of State
    National Marine Fisheries Service
    Drug Enforcement Administration
    Customs Service
    Department of Interior

Department of Defense

State and Local Law Enforcement Agencies

Regional Fisheries Management Councils

Domestic Industry--fishing, mining, other commercial
exploration

United Nations Law of the Sea Conference

International interests in ocean resource extraction

Within this patchwork of agencies the Coast Guard has a
primary operational enforcement responsibility for the
maritime environment.

C. GENERAL LAW ENFORCEMENT PLAN

Presently the fisheries law enforcement program con-
tributes the largest proportion of operational resource time
and efforts of all Coast Guard activities in this mission
area. The general ELT program has the greatest growth
potential. There is no universally accepted definition for
this problem area, its absolute magnitude is not yet known.

The general law enforcement plan developed for Coast
Guard operations is based on four major premises. These
are:

> 1. The Coast Guard has enforcement authority
> for violations involving customs, immigration,
> quarantine and controlled substance laws.
>
> 2. General maritime law enforcement within
> the Coast Guard is increasing, and, by 1989,
> will equal or surpass fisheries law enforce-
> ment efforts.
>
> 3. The U. S. Customs Service, Immigration
> and Naturalization Service, and Drug Enforce-
> ment Administration have law enforcement
> responsibilities involving the maritime
> community, and for which they lack suitable
> resources.

4. The Coast Guard, with its operating
presence in the maritime environment and
its function as the primary maritime law
enforcement agency of the U. S. Government,
is best suited to provide support for
other government agencies involved in
maritime law enforcement. [25:II3-II4)

The plan is set up to facilitate the achievement of ten

year goals through a series of steps. These steps, or

milestones, allow for the systematic development of enforce-

ment capabilities. The major overall ten year goal of the

general enforcement program is to detect and deter 75 percent

of all violations of laws and treaties other than those

relating to fisheries, non-living resources, or those

pertaining to other Coast Guard programs.

The current estimates of enforcement effectiveness

available to the Coast Guard puts the program in the 3

percent to 12 percent range. A figure of 5 percent effective-

ness is commonly used for planning purposes because it is

basically a reasonably conservative estimate. [25:V-31]

The goal of 75 percent effectiveness relates to the gains

made in the first ten year period of fisheries enforcement.

These gains are being projected towards the general enforce-

ment arena with hopes that the same productivity increases

can be realized.

The second major ten year goal commits the Service to

increase cooperation with all other agencies having similar

authority and responsibility for maritime law enforcement.

At the present time none of these agencies have the marine

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resources necessary to successfully pursue a total enforce-
ment action at sea. Greater utilization of these marine
vehicles through inter-agency cooperation would require a
smaller total capital equipment investment by the taxpayer
and would promote the most efficient use of those resources
now in existence.

The third major ten year goal is to increase the
capabilities of patrol units through technological advances
and the utilization of personnel trained in law enforcement
duties. The realization of this goal would allow for a
reduction of resource hours required to accomplish a specific
task. This savings could be applied towards additional
enforcement efforts or other areas of interest to the Service.

The ultimate realization of these goals will require a
dedicated effort by Coast Guard operational and support
personnel. Several key areas have already been identified
as needing immediate attention, while other aspects of the
program can mature at a slower pace.

The intelligence gathering and evaluating functions are
of primary importance. Coast Guard personnel, along with
personnel of the various other federal law enforcement
agencies, are assigned to the El Paso Intelligence Center
(EPIC). EPIC is a computer based, central data collection
point with historical files, current data, and predictive
capabilities. These capabilities are expected to be
instrumental in the determination of future enforcement

requirements. As knowledge of the drug trafficing population, their organization and their methods of operation is acquired, EPIC can provide predictive data to aid Coast Guard operational enforcement efforts.

The total enforcement problem has yet to be defined in manageable terms. There is no known absolute number of crimes committed in the maritime domain. The total amount of drugs smuggled into the country is not known nor is the land/sea/air split on these operations known. This makes it impossible to determine the exact effect any enforcement efforts have on the total national drug problem. [21:11]

As a better understanding of the smuggling operations aimed at the U. S. is gained, every law enforcement agency will benefit. The Coast Guard will be able to revise its enforcement plans and make the necessary resource adjustments in order to achieve a 40 percent success rate by 1985 and the 75 percent success rate by 1990.

It must be remembered that these goals for detecting and deterring crimes at sea hinge on a cooperative effort. It has been proven necessary to establish formal inter-agency agreements with each federal agency involved in the suppression of violations of the customs and navigation laws involving smuggling and contraband along the United States maritime frontiers. [30:1] In addition to these formal agreements, operational commanders have been directed to establish local working agreements or memorandums of understanding (MOU) with associated agency officials.

The main focus of these agreements is generally three-
fold. The agreements tend to promote:

1. The effective utilization of personnel and facilities
through cooperative efforts.

2. Define the nature and extent of the services, systems,
and facilities each agency will provide.

3. Provide for the timely interchange of information
to permit proper planning, programming, budgeting and
evaluation.

Each agency is normally assigned the cooperative duties
that it can best perform. The Coast Guard is tasked with
all at sea enforcement responsibilities due to its unique
maritime resources. Personnel and necessary support equip-
ment are also normally supplied during a joint operation.
Training for other agency personnel in small boat operations
and maintenance techniques and other areas, where Coast
Guard expertise is appropriate, is provided.

Agreements have been concluded with the United States
Customs Service (USCS) and the Drug Enforcement Administra-
tion (DEA). These two law enforcement agencies have agreed
to train Coast Guard personnel in drug identification and
testing techniques. Both agencies provide trained agents
to accompany Coast Guard units on anti-smuggling patrols
where they act as advisors to the unit commanders and
boarding party personnel.

The agreements provide for a general sharing of intelligence information between the responsible agencies. This one factor has now, and will continue to have, a profound effect on the cumulative anti-drug enforcement efforts. The sharing of information through EPIC will allow for more accurate estimates of the problem.

Prior to these agreements there was no way to cross check or verify enforcement results and statistics. A data base is being compiled that will allow for a better scaling of the drug problem. Gross indicators such as world wide and specific area production capabilities, seizure statistics, and aggregate figures based on projected national consumption rates are being compiled and correlated. These indicators are being reviewed and revised continuously and as their degree of credibility is increased, a more accurate definition of the enforcement problem is revealed. [21:10-11]

Technical capabilities of enforcement units must be increased if the stated goals are to be met. Increased research and development efforts must be applied to enforcement vehicles and methods. Productivity gains in enforcement capabilities appear to return great savings in operating time and funds. One estimate of a 5 percent gain over FY 1976 levels would reduce vessel operating days by 100, and aircraft operating hours by 225. This alone would save over $1,000,000 in direct operating costs. [25:V-36] The most recent productivity gains have been made by deploying

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short range recovery (SRR) helicopters on patrol vessels. Future milestones will be to deploy patrol aircraft with sophisticated sensor packages and develop sensor systems for surface craft.

Table I is a representation of expected Coast Guard enforcement efforts through the year 1990. These estimates of the annual resource operating requirements are broken down into milestone levels which indicate a sepcific degree of accomplishment for the program standard. Level I represents the optimum level of performance of the desired goals while Level III represents the current level of operations. The resources are designated in three major classifications. The requirements for vessels (all major cutters) and patrol boats (both 82 foot and 95 foot) are expressed in the number of days on patrol in specific operating areas. The requirements for aircraft, which include both airplanes and helicopters, are expressed in the total number of flight hours within these patrol areas.

The determination of the proper resources necessary to accomplish the desired mission is based on operational characteristics of available or planned resources and various economic considerations. When aircraft are deemed necessary for mission accomplishment, the desired type of aircraft is not always apparent. The program manager has discretionary authority in making that selection. [23:I-1]

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TABLE I

ELT PROGRAM PERFORMANCE LEVEL

GOAL/MILESTONE: Detect/deter violations of U.S. law other than fisheries, and that of other programs.

LEVEL	%	CRITERIA	ANNUAL RESOURCE REQUIREMENT			RESOURCE CHANGE FROM LEVEL III		
			VSL DYS	WPB DYS	A/C HRS	VSL DYS	WPB DYS	A/C HRS
I	100	Detect and deter 75% of the violations of criminal laws of the U.S. in the maritime environment.	3,500 3 SRR Helicopters	2,000	3,000	2,750 3 SRR	1,000	2,350
II	53	Detect and deter 40% of the violations of criminal laws of the U.S. in the maritime environment.	1,500 1 SRR Helicopter	1,500	1,300	750 1 SRR	500	650
III	5-10	Detect and deter 5% of the violations of criminal laws of the U.S. in the maritime environment.	750	1,000	650	0	0	0
IV	2	Respond to reports of violations of U.S. criminal laws in the maritime environment.	400	600	400	-350	-400	-250
V								

Remarks: VSL DYS = Vessel Days   WPB DYS = Patrol Boat Days
A/C HRS = Aircraft Hours   SRR = Short Range Recovery Helicopter
(HH-52A)

SOURCE: [25:V-43]

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The selection of aircraft types for the various ELT

missions is based on differing capabilities. When more than

one aircraft type will satisfy the mission requirements,

economic considerations dictate the type selection.

> Decisions arrived at from a consideration
> of capabilities and costs, have resulted
> in our (Coast Guard) present inventory of
> aircraft and will determine what future
> mix of resources will be appropriate to
> satisfy anticipated requirements. [23:II-1]

III.   THE MANAGEMENT CONTROL PROCESS

This chapter will present an analysis of the present
management control process used to evaluate present general
ELT mission performance and provide inputs for future program
planning needs. The report formats and content will be
discussed. The Sikorsky Aircraft cost/benefit study that
was completed for the Coast Guard will be discussed and
appears in abridged form in Appendix A.

The control process used in conjunction with ELT resources
is similar to that used in most government accounting and
control systems. Costs are recorded as they are obligated
and/or occur for specific purposes, while the resulting
outputs, or benefits, are recorded as those tasks are accom-
plished. Much of this data is easily recorded in a accounting
format. As data is reported it can be tabulated and condensed
in brief summary form. Often the output data cannot be
accurately described in these quantitative terms. Broad,
subjective devices are then used to describe those aspects
of the system's output.

The input, or cost, side of the general ELT mission
control structure is relatively straight forward. Accounting
data is collected for the various aspects of aircraft and
vessel operations. These include obligated and actual air-
craft hours flown, vessel days underway, and fuel consumed.
At the present time no separate account is maintained on

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military personnel costs or other indirect costs of operating these resources while performing ELT duties. This is consistent with most other federal agency practices and policies.

Personnel manning allowances for aviation units are determined solely on a unit's Search and Rescue (SAR) readiness requirements. Law enforcement deployments, whether for fisheries or drug enforcement, are not presently considered. Vessel manning standards are determined for the class and not on a specific mission or specific vessel basis.

In a move to facilitate the accurate quantification of each program area, the Coast Guard, as of 1 October 1978, requires all ELT flight hours to be divided into general law enforcement and fisheries law enforcement elements. This should aid program managers in assessing the future requirements of their programs. It also provides a clearer picture of specific areas of concentration for each law enforcement program. From the limited historical data available, general law enforcement activities have heretofore been concentrated in the Florida and Gulf Coast regions but now appears to be increasingly important in all U. S. coastal regions.

The report's data collected and evaluated by the program manager arrives in various formats. The two most important examples of these formats are the statistical operating summaries and the individual vessel patrol reports which are submitted by every vessel's Commanding Officer upon the completion of each patrol.

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The surface vessel and aviation Abstracts of Operations
are uniform statistical operating summaries which provide
a wealth of information on the input efforts expended on all
missions for which Coast Guard units were employed. These
reports break the operating data down several ways. For
example, aircraft operating hours are tabulated quarterly
and annually, by mission area, by aircraft type, by assigned
unit, by assigned District, and by assigned Area.

Similar statistics are tabulated for all vessel types.
These reports allow the program manager ready reference to
information on his program's inputs. It also provides an
objective picture of each program's share of operating
efforts for all Coast Guard units. This summary provides
a periodic comparison of planned performance level standards
and actual level of performance to date.

To illustrate the interest in statistical reporting and
record keeping, an internal study was completed in April of
1979. This study indicated that out of the 206 seizure cases
studied, 192 were initiated by Coast Guard personnel and that
these Coast Guard units were credited with the seizure. The
vast majority, 163 cases, took place in the Florida/Gulf
Coast region. The study went on to indicate that the primary
resource was a 210 foot Medium Endurance Cutter (WMEC) in
82 of these cases, while the remaining were spread over many
different Coast Guard vehicles. Helicopters were directly
involved in 21 of these cases and 17 were deployed on patrol

cutters. In all cases where the helicopters were deployed, the seizures occurred in the Florida/Gulf Coast region.

Due to the interaction and competition among the various federal enforcement agencies, statistics are kept on arrests and seizures credited to each agency. Those agencies cooperating with the primary enforcement agency get credit for that participation with an assist. The Coast Guard contraband seizure results from 1973 to 1978 are shown in Table II. This illustrates that the efforts to detect and deter marijuana smuggling have been by far the most successful of the efforts against smuggling of controlled substances to date.

Other statistics of interest to the general law enforcement program manager are the number of cases prosecuted by Coast Guard units, the number of vessels seized, the number of arrests, and the quantity and value of all contraband seized. These figures are available from the historic case files maintained by the Service. These figures are viewed as benefits derived from the efforts expended.

The patrol reports submitted by patrol vessel Commanding Officers are far less structured in nature. There are requirements for the inclusion of standard operating statistics, but often a substantial proportion of the content is left to the individual Commanding Officer. These reports generally contain a statistical abstract, a narrative patrol summary, a description of any outstanding problems or failures

TABLE II

GENERAL LAW ENFORCEMENT CONTRABAND SEIZURES BY
CALENDAR YEAR

	1973	1974	1975	1976	1977	1978	TOTAL
Vessels seized by Coast Guard	6	11	5	18	35	109	184
Vessels seized by other agencies with CG participation	1	3	2	10	22	20	58
Marijuana seized by Coast Guard (lbs)	15,700	38,500	94,025	200,568	1,022,799	2,497,115	3,868,707
Marijuana seized by other agencies with Coast Guard participation (lbs)	4,600	4,975	653	145,003	200,315	178,828	534,374
Cocaine seized by Coast Guard (kg)	1	0	0	20	0	0	21
Cocaine seized by other agencies with CG participation (kg)	0	0	0	10.1	0	.03	10.13
Hashish seized by Coast Guard (lbs)	0	6,139	0	0	0	0	6,139
Hashish seized by other agencies with CG participation (lbs)	0	0	2,000	0	1,700	0	3,700
Thai sticks seized by Coast Guard (lbs)	0	0	0	10,185	17,130	0	27,315
Arrests	15	58	28	184	304	651	1240
Street value of contraband seized (millions)	4.79	37.39	34.80	146.42	429.91	970.58	1623.89

Source: U.S. Coast Guard Records

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experienced while on patrol, and recommendations for improving operating performance.

The program manager is continuously called upon to use his personal experience when reviewing vessel patrol reports. Important tactical procedures and beneficial recommendations are proposed in this narrative format without benefit of quantification. This personalized reporting system can accomplish the task of communicating many detailed and complicated field experiences but requires the program manager to continuously rely on his field experience. This reporting format also requires continuity in conception of the problem areas and the suggested solutions. [11:35]

Typically, statements such as the following would be included in a patrol report. "For effective patrol coverage, aircraft support is mandatory." "A patrol without an embarded helicopter is an ineffective patrol." There is no attempt to quantify these claims, and they must be accepted or rejected solely on the judgement of the program manager. This is not meant to imply that this kind of feedback is not important nor of value, but only that it is not quantified by the reporting source.

If there had been no requirement to quantify this feedback, there must be some basis for its continued acceptance. In fact, it is unanimously accepted by high level staff personnel that the ship/helicopter team is a most effective combination even though it has never been quantified in

actual tactical situations. [25:V-22] This belief is rooted in the acceptance of two major theoretical studies conducted using the fisheries law enforcement mission as their subject area.

The first of these studies was completed for the Coast Guard by Sikorsky Aircraft Division of United Technologies Corporation in May of 1973. The purpose of this study was to develop a cost/benefit ratio to demonstrate the relative savings of using helicopters to conduct large area patrols while they are deployed on flight deck equipped cutters.

The helicopter was required to locate and rendezvous with fishing vessels of any nation in order to check that they were not violating the laws. This was then compared to Coast Guard cutters proceeding from ship to ship making the necessary inspections. This method normally gave the violator the opportunity to haul in its gear and give the appearance of innocence. The helicopter was intended to offer the potential of surprise. It is small in size making it hard to see, and its superior speed allowed it to cover greater distances in minimal time. Although this study was conducted using specific equipment and the dollar amounts are expressed in 1972 terms, it does give a useful comparison of the relative cost/benefit ratio experienced using typical Coast Guard ships and helicopters.

The two major conclusions of this study were impressive because they dramatically confirmed what had always been

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believed. The ship/helicopter team was able to cover the same area of ocean 3-18 times faster with a cost reduction of 1.5-9 times as a ship operating alone. These ranges were dependent on vessel speeds varying from 5 knots to 30 knots while the helicopter maintained a constant speed of 100 knots. These results allowed a great increase in patrol area coverage with a proportionally small resource investment.

The complete derivation of these cost and time ratios is found in Appendix A.

IV. ALTERNATIVE PROGRAM EVALUATION METHODS

A. EVALUATION GUIDELINES

The evaluation process of the ELT program results is one of the more critical management areas for the Coast Guard. What process is or should be employed to determine the outcome (the ultimate effect of the program outputs) of all efforts spent on general law enforcement? There are several echelons in the evaluation process, with each contributing to the final answer. The desired conclusion should be an accurate comparison of the ELT program outcomes to what the written goals and objectives are for that program.

The goals and objectives of any program should be statements of intended output. Goals are generally broad statements which are not quantified and generally cannot be used directly as a basis for a measurement system. Objectives, on the other hand, are statements of specific results to be realized within a specified time period [2:133].

An overview of Coast Guard goals and objectives for general law enforcement was presented in Chapter II of this paper. There are several questions that should be directed toward these statements to determine whether or not these goals and objectives can be met and/or measured after being met.

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The statement of objectives should be as specific and quantitative as possible. It should state what is to be accomplished and by when, but not discuss the associated "why" and "how" aspects of each objective. The objectives should also be realistic and attainable and must be consistent with the resources available or anticipated. These basic guidelines are adhered to by the Coast Guard general law enforcement goals and objectives statements. The broader goal statements communicate the aims of general law enforcement and give the basic priority each has in the ELT structure. Some guidance is given as to how these goals should be pursued, but this is nonspecific in nature.

The statements of the objectives of general law enforcement are much more specific than the goal statements. A step by step method for accomplishing the law enforcement goals is presented through the program objectives. These steps appear in sufficient detail as to suggest the intended method of accomplishment. Finally, a time table for the successful accomplishment of these steps is given in the statements of objectives.

The ELT manager must have basic data upon which to make evaluations of that program. This data is reported in various formats but is normally consistent with the program standards expressed at the headquarters level in the program plan. Usage data is transmitted to all management levels concerning vessel days on patrol, aircraft hours and sorties

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flown, fuel consumed, vessels sighted and/or boarded,
quantity and street value of all controlled substances
seized, number of vessels seized, and arrests made.

B. RESOURCE EVALUATION

A set of guidelines was developed to aid in the planning
and actual employment of various enforcement vehicles. In
May of 1976, the Study of the Coast Guard Enforcement of
the 200-Mile Fisheries Conservation Zone was completed.
It described the necessary enforcement efforts required
to properly manage the fisheries resources in this new zone.
To illustrate its current applicability, the following has
been extracted from the study and rephrased so as to present
the general enforcement resource planning and evaluation
requirements.

The functional elements of the maritime law enforcement
system include detection, surveillance, and apprehension of
the activities in question. It is of great importance to
know how each piece of equipment fits into the system's
framework. The strengths and weaknesses of the helicopter
as an alternative in the law enforcement system must be
determined.

The elements of the law enforcement system must be
defined irrespective of any enforcement scheme chosen to
implement that system. The elements cannot be solely depen-
dent upon "currently available" options, but must be stated
in terms of the desired results. These results can be
described as:

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1. Detection

The detection element deals with the knowledge of
the existence of vessels and the activity levels within an
area of concern. This knowledge means that the object can
be identified as a vessel of interest to the enforcement
agency.

2. Surveillance

The surveillance element is the monitoring element
of the system. It provides detailed information in order
to categorize a vessel's activity and obtain detailed
operating data. In order to enforce the law, there is the
requirement that the courts must be satisfied as to the
following:

a) Is the vessel engaged in smuggling?

b) What substance is being smuggled?

c) What is the amount of the substance?

d) Is the vessel in violation of established laws
or regulations?

e) It is important under the surveillance element
of enforcement scheme to gather other informa-
tion which will help in the administration of
the law.

3. Apprehension

When it is determined that a vessel is in violation
of U. S. laws or regulations, there must be the ability to
apprehend, detain, or continue tracking the violator until
an arrest or other action can be concluded.

There are several alternatives in existence that could be used to conduct the enforcement program. The helicopter and the ship/helicopter team are examples of these alternatives. In order to rate the success of any functional element one has to look at its capabilities in detection, surveillance, and apprehension. The tasks associated with each of these functional elements are as follows:

a. Detection Element

1) Detection of the vessel.

2) Initial classification of the contract.

3) Identification of the vessel (nationality, type, hull numbers, number of persons on board).

4) Verification--the ability to ensure that all vessels in the area have been located and identified.

b. Surveillance Element (Determination of)

1) Vessel activity--is the vessel engaged in smuggling?

2) Type of the substance on board.

3) Amount of the substance on board.

4) Administrative information--point of origin, point of destination, methods of transfer of the substance, value of the substance.

c) Apprehension Element

    1) Notification of violator.

    2) Initiate/maintain "hot pursuit."

    3) Apprehend the violator.

Hot pursuit is requisite under international law to preserve the jurisdiction of the coastal state over a vessel which violates its laws and then flees to the high seas beyond the jurisdictional "zone" where the offense occurred. Hot pursuit must be established within the jurisdictional zone by giving a visible sign to stop, and continuous visual or radar contact must be retained thereafter until the vessel is boarded and seized. Once hot pursuit is broken, coastal state jurisdiction over the violator ceases.

Each enforcement option can be rated against these functional tasks in several ways. A statement of the pros and cons of each option can be made with a subjective rating or measurement determined from that statement. In certain instances, objective measurements can be made of the option's performance or potential performance of the functional tasks. A combination of these measurement schemes could show the relative strengths and weaknesses of the helicopter and the ship/helicopter team.

A logical assessment of helicopter and ship capabilities could be made using historical operating data in combination with a rating system designed for the fisheries

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enforcement system. This system gives an indication of the relative ability of an enforcement vehicle to perform the required tasks for detection, surveillance, and apprehension. The parent study considered several vehicle options which were not applicable to the drug enforcement program, although the resulting ratings are still useful in making general comparison.

For the detection function, both helicopters and ships satisfy the requirements with few exceptions. Both options can establish the presence and identify of vessels in an area, provide visible expression of active interest and control, provide a deterrent to potential violators, and provide the required verification of compliance with the laws and regulations. The two major differences between these options are the helicopter's speed allows for greater area coverage, and the ship's physical presence allows for more complete verification and exerts the maximum possible deterrent effect. The major drawback for each option in performing the detection functional tasks is their high cost.

The similarity in their abilities to satisfy the requirements is not repeated for the surveillance and apprehension functions. For the surveillance function, the helicopter can only monitor the external activity of a vessel, but it can be expected to perform this task over a large ocean area. It cannot provide any detailed or internal information from a sighting.

A ship, on the other hand, is well suited to perform all of the tasks required for effective surveillance. It can provide, through detailed onboard inspection, a determination of the presence of controlled substances, the type, the quantity, and any other information useful for the enforcement of smuggling laws. The ship is the only platform from which to dispatch and disembark boarding parties, and thus presents a large deterrent effect. Both options again present high input costs to perform these tasks.

The helicopter can satisfy only the requirement to establish and maintain hot pursuit for the apprehension function. Its major drawbacks are its limited endurance and inability to safely disembark a boarding party. The ship can also establish and maintain hot pursuit but again lacks the aircraft's speed. It can support and provide protection for embarked boarding parties and is the major factor in completing the apprehension function.

The capabilities of both helicopters and ships to perform these required functional tasks suggests a series of criteria for their performance evaluation. Helicopters are used to conduct patrols and provide wide area coverage to determine vessel presence and activity, and to initiate necessary enforcement action. Ships, whether in conjunction with a deployed helicopter or shore based aircraft support, conduct patrols, boardings, monitor vessel activity and apprehend violators. These resources, and their contribution to the program's outputs, should be evaluated accordingly.

There are several methods of evaluation of any program's outputs. They can be used to distinguish between various levels of objectives or can be used to distinguish different categories of effect or outcomes. Each program should be evaluated in each of the five categories described as follows.

C. EFFORT

The criterion of success in this category is based on quantity of effort and level of activity generated within the program. It is normally an assessment of inputs rather than a measure of outputs. It is used to identify what has been done within that particular program area. Evaluating effort is generally considered the easiest evaluation technique and therefore many managers stop there. It is easier to maintain accounting records than to evaluate the success of efforts.

The capacity for effort or the effort itself is the basis for the category milestones. An assumption must be made that the specific effort is a valid means for attaining the intended goals. Effort alone does not provide the total answer for the manager but it does provide some useful information. These figures will show not only what has been done, but will also give a picture of the capacity for activity among the available resources.

Evaluations of vessel days on patrol flight hours, fuel consumed, vessels seized, arrests made, and amounts of controlled substances confiscated are all examples of

evaluation of effort. This type of evaluation is important,
but it stops short of determining whether the program has
accomplished anything worthwhile.

D. PERFORMANCE

The performance or effect criteria measures the results
of the effort, rather than the effort itself. For this to
be possible, clear statements of the objectives are required.
This criteria determines what has been accomplished towards
the stated gaols of the program. It measures any changes
in the original state, and whether or not these changes were
the ones intended. The specific changes that must be measured
in this case would be the resulting effects on smuggling
activity caused by the program efforts in general and the
marginal contribution to that change by a specific resource
employed therein.

In order that performance can be evaluated, key assump-
tions normally have to be made. In the case of general
enforcement, program performance levels were developed by
using seven key assumptions. These assumptions are:

> 1. The estimate of participating general
> enforcement agencies for their effectiveness
> against violators vary from 3 percent to
> 12 percent. The Coast Guard effort lies
> somewhere between these values, and is
> assumed to be 5 percent.
>
> 2. Crimes are committed by a segment of the
> total population which is usually on the
> average of 1 percent. This percentage is
> valid for maritime law violations.

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3. Boats of less than 26 feet will not
conduct significant illegal activities and
are not considered.

4. The common elements of surveillance,
detection, and apprehension in fisheries
and general enforcement make comparisons
of effectiveness possible. The shape of
the cost/benefit curve for both missions
will be identical.

5. The magnitude of the general enforcement
problem is equal to or greater than the
fisheries enforcement problem.

6. The laws pertaining to the importation
of controlled substances will remain
essentially unchanged during the 10 year
planning period.

7. Enforcement efforts will be directed
toward an economic zone extending to 200 miles.
[25:V-37 - V-38]

These assumptions were developed through general law

enforcement statistical surveys or from current in-house

expertise. Assumption #1 was derived from estimates of the

total regular marijuana users and the amounts necessary to

sustain their annual demand. Assumption #4 is based on the

results of an Enforcement of Fisheries Law and Treaties

Study completed in 1972. This study was undertaken to

quantify the elements of fisheries law enforcement and to

develop a mathematical model to evaluate resource types and

levels against specified system goals.

Problems do exist with the general enforcement performance

evaluation because the fisheries study was also based on

several assumptions. One of those assumptions was that

fishermen do not intentionally set out to violate the law,

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but there is a probability that he will violate a statute,
treaty, or agreement. This probability was estimated and
the effect of deterrence was incorporated into the study.
[24:5] This assumption does not apply to the general enforce-
ment program because anyone engaging in smuggling is inten-
tionally and consciously violating the law. His probability
of violation is 1.0 and not that of a fisherman which is
something less than 1.0. This affects the shape of the
cost/benefit curve but will not change the performance of a
helicopter while conducting patrol flights.

The effectiveness of the interdiction efforts, by
definition, are always based on estimates of the current
supply and demand situation. That portion of the undetected
illegal drugs imported by land and air is not presently
known nor is there a reasonable estimate. Also, it is not
known if demand is equal to the available supply plus that
amount interdicted or just equal to the amount available for
current use.

Finally there is an implicity assumption that must always
be made in performance evaluation. All reported data is
assumed to be valid and reliable unless significant
modifying conditions are specified by the reporting source.

E. ADEQUACY OF PERFORMANCE

This criteria addresses the degree to which effective
performance is adequate to the expressed need. In this sense

adequate is a relative measure based on the level of the expressed goals. It is a measure of performance based on the denominator of total need.

One common index of adequacy is to multiply the effectiveness ratio by the number of subjects exposed to the program. Programs with high exposure but relatively low effectiveness may have an acceptable impact. The opposite can also be true when the situation is reversed. It is now necessary to continuously monitor the program to confirm that these milestones are being accomplished in a timely fashion.

A realistic awareness of what is possible at any one time given the state of technology and the resources available and expected is essential. An incremental process must be utilized when judging adequacy rather than basing each effort on the ultimate goals. This has been taken into account for Coast Guard general law enforcement through the establishment of incremental milestones. The ultimate goal of 75 percent detection and deterrance of all violations, although not possible at this time, is projected to be met through a series of technological and productivity gains. Each milestone provides an incremental step towards that goal.

F. EFFICIENCY

Efficiency is the evaluation of a program in terms of costs--in money, time, personnel and resources. Cost/ benefit ratios are often used to compare the results of

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those efforts to the actual costs incurred. Efficiency can
be viewed as outputs divided by inputs. [2:19]

This evaluation technique must be carried further than
just a cost/benefit comparison. The program should be
periodically reviewed to determine whether its goals are
being accomplished in the most efficient way. Is there a
better way, has technology advanced to a point where the
present methods are creating disproportionate costs in other
program areas? These are the questions for which managers
must seek the answers. "Such questions point out that
standards of performance will improve if they consider the
effort-costs involved and arrive at comparative efficiency
ratings." [18:65]

Appendix A is an illustration of the relative efficiency
of the helicopter while being employed to patrol large open
ocean areas. The relative and absolute gains in costs and
time over that available using only a ship are dramatic.
This satisfies the first part of the efficiency evaluation,
but one should seek out other methods for this patrol
function. Could other vehicles such as satellites do this
function in a more cost effective and efficient manner?

G. PROCESS

The analysis of the process by which a program produces
its results is not normally a formal part of the evaluative
function. Often the "hows" and "whys" of the success or
failure of a program cannot be learned from the analysis

described in the preceding criteria because data is collected solely to indicate only success or failure.

The analysis of the process, or method by which a program is accomplished, may help to explain the reasons for unexpected program results. Important aspects of the process analysis would be to determine which attributes make the program a success or failure, and under what specific conditions did they occur. Once the causes are located, modifications could be made to revitalize the program instead of perhaps discarding it as a failure.

V. CONCLUSIONS AND RECOMMENDATIONS

This thesis has examined the performance evaluation system currently used in the Coast Guard general law enforcement program. This examination was conducted using the helicopter as the representative example of the program's operating resources and focused on the requisite management information and evaluation systems necessary to assure the efficient and effective utilization of the available and anticipated resources.

Three major assumptions were necessary for this study. It was limited to the comparison of the helicopter and the ship/helicopter team for two reasons. It was believed that an accurate representation of the program resources could be shown using only these options, even though many other types of vehicles are also used. Secondly, it was assumed that the general and fisheries enforcement programs are comparable, and the ship/helicopter option is the most familiar subject for such comparisons.

An assumption was made that only Coast Guard resources were available for maritime enforcement activities on a scale large enought to be successful. No other agency had the necessary resources and they would gain their maritime support from the Coast Guard. The necessary cooperation and coordination would be provided as needed to ensure the success of all joint operations.

The smuggler was taken to be a totally rational partici-
pant in his chosen endeavors. The risks of being apprehended
by enforcement authorities were far outweighed by the
expected returns. He would normally conduct his activities
in areas where he was least likely to be subject to any
enforcement actions.

The Coast Guard has been an active participant in law
enforcement since its inception. The Prohibition Era provided
an excellent precursor of the present anti-smuggling
activities of the Service. Out of the "Roaring Twenties"
came a generally accepted social disrespect for the law,
and this disrespect is in existence today. The only major
difference between Prohibition and the drug trade is the
lack of popular support for the total legalization of drugs.
This was a key factor toward the end of Prohibition influ-
encing all levels in the enforcement community.

The political environment in which the Coast Guard has
been attempting to fulfill its law enforcement goals has
been, in many respects, hostile to that end. The contra-
dictions of purpose within the top circles of national
politics have demanded that every federal program be looked
at in much closer detail. Legislative mandate has required
renewed and expanded enforcement efforts in the anti-
smuggling arena. At the same time, tremendous pressure has
been applied to balance the federal budget and bring spending
under stricter controls. These budget restrictions have

greatly added to the importance of complete program performance evaluations.

The system presently employed for the general law enforcement program evaluation was reviewed with the aim of discovering what was being evaluated and the historical data base being used for this comparison. It was discovered that the Sikorsky Aircraft report of 1973 formed the basis for the helicopter resource evaluation as a member of the ship/ helicopter team. This study illustrated that the ship/ helicopter team is effective for large ocean area patrol coverage. It also proved that this is an efficient method of using this resource combination. Little or no changes have been introduced since it was first adopted, and its continued support is based on the confidence of the senior managers with these findings.

The program report formats were reviewed to determine what information was being submitted to the program managers for evaluation. The reports consisted of statistical data dealing solely with input parameters and a narrative section containing feedback on tactical situation descriptions and general comments and recommendations. The data presently provided requires the program manager to have extensive personal field experience with each aspect of the program in order that he can maintain a continuity in problem conception and recommended solutions with his operational commanders.

An alternate and expanded program performance evaluation system has been presented and is recommended. This system will allow for the determination of not only the efforts expended on a program, but will allow for viable measurements of its outputs. The requirements for a program's continued existence are reviewed and the basic efficiency of its resource utilization is determined.

The basic idea of complete program evaluation for the identification of the benefits derived from the ELT program is necessary due to the nature of Coast Guard personnel policies and its dynamic mission requirements. As new programs are added and current programs are expanded, management skills and experience will be taxed to form accurate judgements on increasingly complex and costly enforcement options. As the violators of the Customs and Navigation Laws become more sophisticated, increased resources will have to be employed to counter this threat. Weaknesses in the program must be identified and adjustments made during the subsequent planning and programming phases in order to keep the general enforcement program viable.

Often the outputs, or results of a program, are difficult to quantify. Law enforcement efforts present this problem to the program manager. Surrogate measures must often be found to represent the benefits produced by the accomplishment of the program's objectives. Further study is needed in the area of the social benefits which result from anti-drug

enforcement. These benefits must be identified and
quantified if adequate fiscal support is to obtained for
its continuation.

The traditional matrix organization of Coast Guard
management has caused an imbalance of power among program
managers, operational commanders, and support managers.
This structure tends to hinder the effective control and
evaluation of the law enforcement program. Often, the chain
of authority does not correspond with the associated chain
of responsibility. Support managers can control such program
inputs as personnel, money, technology, and information but
they are not held responsible for the program outputs. A
detailed reorganization of the management structure along
program lines would increase effectiveness and reduce many
of the existing conflicts.

Much more can be done to continue the analysis of the
decision and evaluation process within the ELT program area.
This is one of the most dynamic areas of Coast Guard
endeavor. As efforts are increased, decisions based on
program evaluations will have a greater impact on all
associated programs. This study has taken a first step in
developing improved program evaluations, but further study
is required.

APPENDIX A

ENFORCEMENT OF LAWS & TREATIES (ELT)

This is a study conducted for the U. S. Coast Guard by
Sikorsky Aircraft Division of United Technologies Corporation.
The concept is to employ a helicopter (HH-52A), operating
from a flight deck equipped Coast Guard cutter, to survey
areas of ocean in which fishing for certain species is
prohibited. The helicopter is required to locate and rendez-
vous with fishing vessels of any nation in order to check
that they are not violating the laws.

Rules of thumb have been developed to help calculate
the improvements to be expected in time and cost by employing
HH-52/ship teams over the ship alone. These are for HH-52A
and USCGC Stories:

Time improvement $\dfrac{100}{V_s} \times \dfrac{D_H}{D_s}$

$(D_H < 25NM, AZ > 8000 \ NM^2)$

Cost improvement $\dfrac{50}{V_s} \times \dfrac{D_H}{D_s}$

where D_H = helicopter detection capability (NM)

D_s = ship detection capability (NM)

V_s = ship speed (kt)

Source: Ref [12]

DETERMINATION OF RULES OF THUMB
COST RATIOS, TIME RATIOS

Operation with Ship Alone

Time to search area AZ is given by:

$$T_s = \frac{(AX - D_s^2)}{2D_s V_s} \quad \text{hours}$$

where D_s = detection capability of the ship (nm)

V_s = velocity of the ship (kt)

Therefore, cost to search area AZ is given by:

$$C_s = \$_s \times T_s$$

where $\$_s$ = operating cost of the ship ($ per hr)

Operation with Ship/Helo Team

Time to search area AZ is given by:

$$T_{S/H} = \frac{AZ}{A_H} \times TH$$

where A_H = area viewed by helicopter in one sortie period

TH = one helicopter sortie period

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The maximum area that can be covered by the helo is given by:

$$A_{H_{max}} = 2 \times D_H \times DH + \pi D_H^2$$

where   DH = distance helo flies in one sortie period

D_H = detection capability of the helicopter

It can be seen from Fig. 1 of the main text that if the detection capability of the helicopter (in nm) is of the same order of, or less than, the velocity of the ship (in kt) then the area viewed by the helicopter is approximately equal to, but in general a little less than, this maximum value. Thus,

$$A_H \sim A_{H_{max}} \qquad (for\ D_H \leq V_s)$$

$$= D_H \times (2 \times DH + \pi D_H)$$

Therefore,

$$T_{S/H} \sim \frac{AZ \times TH}{D_H(2 \times DH + \pi D_H)}$$

This time represents the flight time of the helicopter.

The helicopter makes AZ/A_H sorties. The end of each sortie requires that some time RFL be spent refueling. Thus, one sortie period for the ship is TH + RFL, and hence the operating time of the ship for this mission is:

$$T_{ship} = \frac{AZ}{A_H} (TH + RFL)$$

$$= \frac{AZ \times (TH + RFL)}{D_H \times (2 \times DH + \pi D_H)}$$

Therefore the cost of the operation = $\$_H \times T_{S/H} + \$_S \times T_{ship}$

where $\$_H$ = operating cost of the helicopter.

Therefore,

$$C_{S/H} = \frac{\$_H \times AZ \times TH}{D_H(2 \times DH + \pi D_H)} + \frac{\$_S \times AZ \times (TH + RFL)}{D_H(2 \times DH + \pi D_H)}$$

$$= \frac{AZ}{D_H \times (2 \times DH + \pi D_H)} \times (\$_H \times TH + \$_S \times (TH + RFL))$$

Time Ratio

$$\text{Time Ratio} = \frac{\text{Time to do job by ship alone}}{\text{Time to do job by ship/helo team}}$$

$$= \frac{T_S}{T_{ship}}$$

$$\text{Time Ratio} = \frac{(AZ - \pi D_S^2)}{2 \times D_S \times V_S} \times \frac{D_H \times (2 \times DH + \pi D_H)}{AZ \times (TH + RFL)}$$

For the HH-52A:

$$DH = 380 \text{ nm}$$
$$TH = 3.62 \text{ hr}$$
$$RFL = 0.5 \text{ hr}$$

Therefore:

$$\text{Time Ratio} = \frac{(AZ - \pi D_S^2)}{2 \times D_S \times V_S} \times \frac{D_H \times (760 + \pi D_H)}{AZ \times 4.12}$$

The maximum ship detection capability employed in this study is 50 nm. Thus, for large enough values of AZ (greater than 8000 sq nm, say):

$$\text{Time Ratio} = \frac{D_H \times (760 + \pi D_H)}{2 \times D_S \times V_S \times 4.12}$$

$$= \frac{D_H \times (760 + \pi D_H)}{8.24 \times D_S \times V_S} \qquad \text{i.e., independent of AZ}$$

For small enough values of helicopter detection capability (less than 25 nm, say):

$$\text{Time Ratio} = \frac{760 \times D_H}{8.24 D_S V_S} = \frac{92.3 \times D_H}{D_S \times V_S}$$

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Note: Since the area searched by the helicopter in one sortie is generally less than $A_{H_{max}}$, due to overlap as explained, the time ratio will be larger than that given by this relationship. Estimates from Figure 1 show that $A_H \sim 0.9 \times A_{H_{max}}$. Thus:

$$\text{Time Ratio} \sim \frac{100 D_H}{D_S V_S}$$

For equal detection capabilities:

$$\text{Time Ratio} \sim \frac{100}{V_S} \qquad (D_S = D_H)$$

Cost Ratio

$$\text{Cost Ratio} = \frac{C_S}{C_S/H}$$

$$= \frac{\$_S \times (AZ - \pi D_S^2)}{2 \times D_S \times V_S} \times \frac{D_H \times (2 \times DH + \pi D_H)}{AZ(\$_H \times TH + \$_S(TH + RFL))}$$

For the HH-52A:

$$DH = 380 \text{ nm}$$

$$TH = 3.62 \text{ hr}$$

$$RFL = 0.5 \text{ hr}$$

$$\$_H = 391 \text{ dollars per hour}$$

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For the STORIS: $\$_S$ = 342 dollars per hour

Therefore,

$$\text{Cost Ratio} = \frac{342(AZ - \pi D_S{}^2) \times D_H(2 \times 380 + \pi D_H)}{2 \times D_S \times V_S \times AZ(391 \times 3.62 + 342(3.62 + 0.5))}$$

$$= \frac{0.0605(AZ - \pi D_S{}^2) \times D_H(760 + \pi D_H)}{D_S \times V_S \times AZ}$$

The maximum ship detection capability employed in this study is 50 nm. Thus, for large enough values of AZ (greater than 8000 sq nm, say) and for small enough values of D_H (less than 25 nm, say):

$$\text{Cost Ratio} \sim \frac{0.0605 \times D_H \times 760}{D_S \times V_S}$$

$$= \frac{46 \times D_H}{D_S \times V_S}$$

As before, $A_H \sim 0.9 \times A_{H_{max}}$

Therefore,

$$\text{Cost Ratio} \sim \frac{50 \times D_H}{D_S \times V_S}$$

For equal detection capabilities:

$$\text{Cost Ratio} \sim \frac{50}{V_S} \qquad (D_H = D_S)$$

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OPERATING COSTS

SHIP	Annual Operating Cost		Annual Operating hrs.		$/hr.	
	1970	1971	1970	1971	1970	1971
STORIS	782,739	694,496	1555	3869	503	180
210	* 529,200	582,735	2807	3047	189	191
378	#1,284,801	1,449,176	5597	4019	230	361

* Avg. operating cost over 16 ships
# Avg. operating cost over 9 ships
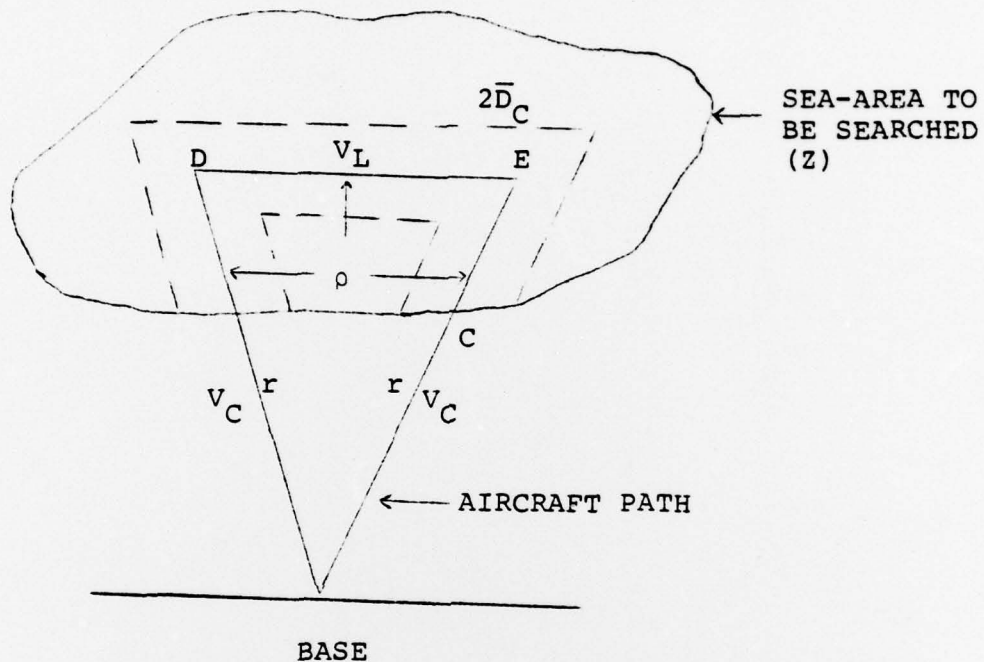
Average operating cost over last 2 years:

SHIP	$/HR	SORTIE COST ($)
STORIS	342	1238
210	190	688
378	296	1072

HH-52A annual operating cost (2 crews) $391/hr.

   One HH-52A sortie cost $1415

DETERMINATION OF COST RATIOS

Assumed Aircraft Flight Path

Distance travelled while loitering

$$\rho = (0.9F_L - \frac{2r}{SR_C})\, SR_L$$

where

$$\frac{2r}{SR_C} = \text{fuel burned in cruise}$$

$$(0.9F_L - \frac{2r}{SR_C}) = \text{fuel remaining for loiter}$$

$$\rho = \overline{BDEC} \quad \text{(Search Distance)}$$

$$0.9F_L = \text{Total fuel - 10\% reserve}$$

$$r = \text{distance out from shore}$$
$$SR_C = \text{specific range at cruise speed}$$
$$SR_L = \text{specific range at loiter speed}$$

Area searched in loiter (A)

$$A = 2D_C\rho \quad \text{per sortie}$$

where

D_C = detection capability of the aircraft (N.M.)

$2D_C$ = width of rectangle

Cost ratio

$$\text{cost ratio} = \frac{Z}{2D_C\rho}\left(\frac{2r}{V_C} + \frac{\rho}{V_L}\right)\frac{\$F.H.}{*C_{S/H}}$$

where

$$\frac{Z}{2D_C} \times \left(\frac{2r}{V_C} + \frac{\rho}{V_L}\right) = \text{total flight time}$$

Z = area to be searched

V_C = cruise speed

V_L = loiter speed

$\$F.H$ = direct cost of aircraft

$C_{S/H}$ = ship helo cost to search 100,000 Sq. N.M.

Enforcement of Laws and Treaties (ELT)

Ship/HH-52A Teams vs. ship alone

SUMMARY

The analysis compares U.S. Coast Guard cutters with HH-52A/ship teams performing the ELT mission. The main conclusions are:

(1) The ship/HH-52A team can cover the same area of *ocean* 3-18 times faster than the ship operating alone for equal ship and helicopter detection capabilities and ship speeds from 5-30 kt.

(2) This time improvement is accompanied by a cost reduction of 1.5 - 9 for the same conditions specified above.

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